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HIGHWAY NOISE

By John L. Beaton*

A spokesman for the Federal Highway Administration was recently quoted as saying "A highway may someday be as wide as its noise pattern." This statement was probably made somewhat with "tongue in cheek", but it certainly emphasizes the problem. So much so that it behooves all of us to become more knowledgable in the field of highway noise. Especially people such as you who are in constant contact with the public. For instance, the above quote, if put into practice, could mean purchasing an additional 300 to 1000 feet of extra right-of-way on each side of a highway. Figure 1 which is a plot of real life traffic noise illustrates the distances required under various conditions before a truck noise is attenuated to various levels.

Sound is an interesting, natural phenomena that occurs whenever and wherever there is movement. Too much sound is usually classified as noise and is disturbing in some degree to most people. Interestingly, the absence of sound also can be disturbing to most people.

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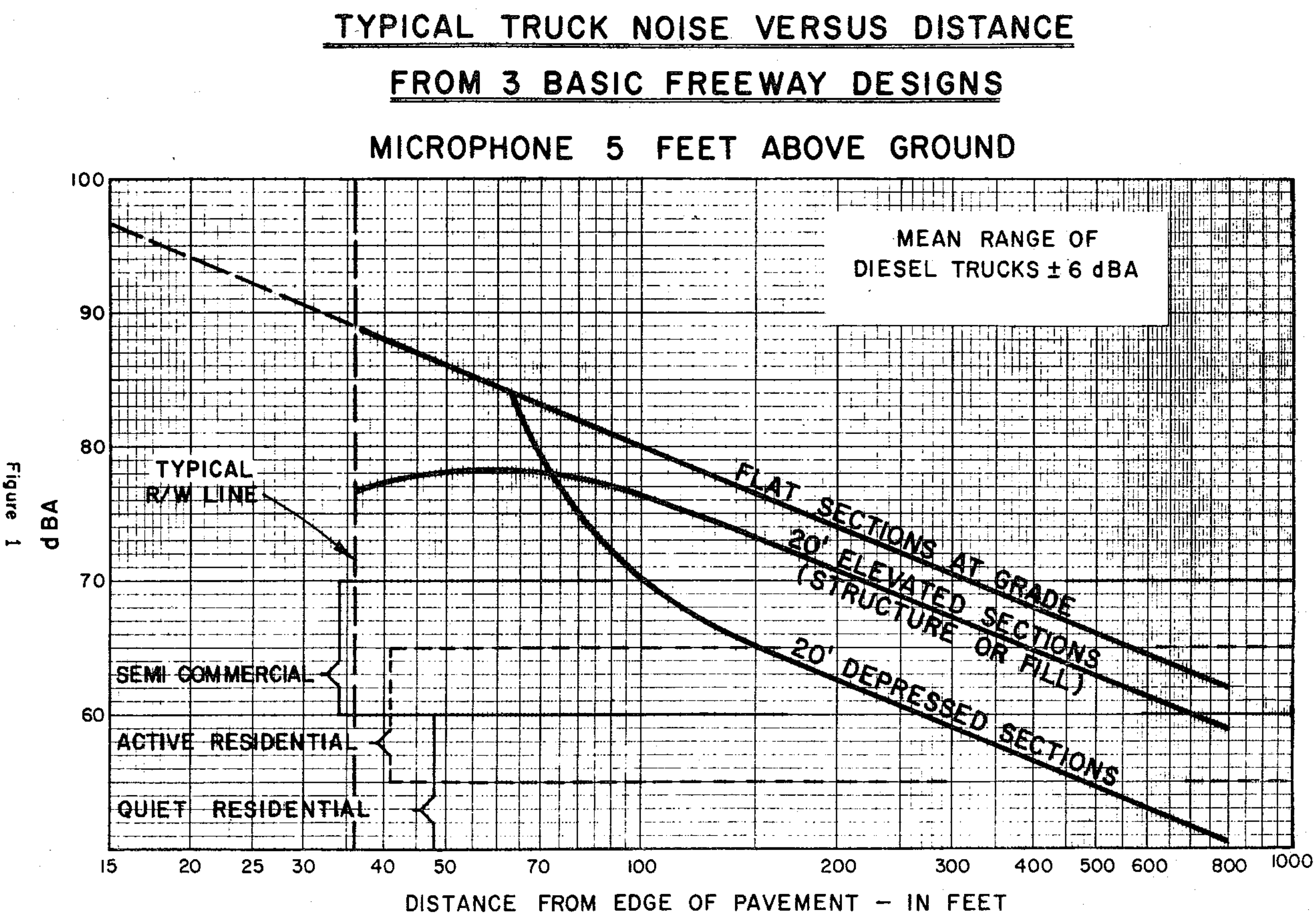
TYPICAL TRUCK NOISE VERSUS DISTANCE
FROM 3 BASIC FREEWAY DESIGNS
MICROPHONE 5 FEET ABOVE GROUND
MEAN RANGE OF
DIESEL TRUCKS ± 6 dBA
TYPICAL
R/W LINE
FLAT SECTIONS AT GRADE
20' ELEVATED SECTIONS
(STRUCTURE OR FILL)
20' DEPRESSED SECTIONS
SEMI COMMERCIAL
ACTIVE RESIDENTIAL
QUIET RESIDENTIAL
dBA
100
90
80
70
60
15
20
25
30
40
50
70
100
200
300
400
500
600
800
1000
DISTANCE FROM EDGE OF PAVEMENT – IN FEET

Figure 1

It has been fairly well established that noise above 75 dBA effects several physiological changes [1] in man, however the psychological effects are less well known. It is known that man adapts rather well to his environment including a wide range of noise. Scientists for these reasons are somewhat reluctant to select maximum noise levels for specific cases. However, certain general levels have evolved in various laws and standards for use in planning, design and noise level enforcement. For instance, here in California we have a State law that prohibits classroom sound level penetrations above 50 dBA from highway vehicles. In addition we have various legal vehicle noise emission laws. These legal requirements are real life sound level readings.

The selection of 50 dBA probably came from the usually accepted maximum level of speech interference. Table 1 indicates the reaction to various real life noise levels by people living alongside of controlled access highways here in California. For application to Federally financed highways the exterior limits are 60 dBA (quiet park areas, etc.), 70 (living units, schools, etc.), 75 (other), and 55 (interior of living and teaching areas) as established by FHWA PPM 90-2. These levels are computed and may be exceeded 10% of the time. They do not necessarily correlate with direct readings.

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[1] Noise as a Public Health Hazard; Ward, W. Dixon; Fricke, James E.; Proceedings American Speech and Hearing Assoc. Feb. - 1969

Table 1

PUBLIC REACTION TO HIGHWAY NOISE

dBA	LOUDNESS*	PUBLIC PROTEST
90	4 TIMES AS LOUD	
		EXTENSIVE
		MODERATE
80	2 TIMES AS LOUD	
		SOME
70	REFERENCE	POSSIBLE
		RARE
60	1/2 AS LOUD	
		ACCEPTANCE
50	1/4 AS LOUD	

*NOTE: dBA is normally expressed on a logarithmic scale and each change of 10 dBA indicates a tenfold increase in sound pressure or intensity whereas in so far as the average human ear is concerned each 10 dBA increase indicates an approximate doubling of the noisiness.

Here in California we have found that most complaints are because of sleep disturbance of residential occupants, followed by daytime speech interference on patios and in schools. Hospital complaints have become minimal probably because most California hospitals are now air conditioned and have closed windows.

We have been using 70 dBA, the average of actual truck peaks, in sensitive exterior areas as a control on whether corrective treatment is needed. This selection was based on many complaints received over the past 20 years subjectively rated as shown in Table 1. It is within reasonable agreement with the Federal requirements. In our particular case California noise projections are based on hundreds of measurements of real traffic whereas most other projections are based on a computed prediction [2]. Required design levels may be selected at any point considered reasonable [3] such as L10. L10 means that the selected level may be exceeded 10% of the time.

Unfortunately the relatively simple process of measuring and predicting traffic noise has been somewhat confused by many well meaning people attempting to computerize (or confuse) the problem. This is also somewhat further confused by the

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[2] National Cooperative Highway Research Program Report 117 Highway Research Board, 1971.

[3] Federal Highway Administration - PPM 90-2, February 8, 1973.

more sophisticated people engaged in what J. H. Botsford [4] calls "The Weighting Game." In this game the researcher, noisemaker and consultant keep passing formulas around without ever making a decision, to the chagrin of the public, thereby keeping the picture well blurred and unresolved. Needless to say evidence surrounds us in the transportation field that the public no longer is tolerant of procrastination in solving the problem.

The overall strategy accepted by most transportation experts to solve the human dilemma of traffic noise is to use a systems approach. There are three major parts of this systems solution, (1) quieten the vehicle, (2) zone the affected area to noise insensitive uses, and (3) incorporate noise reduction features in highway design. The present "State-of-the-Art" technical and financial features involved precludes creating a "quiet enough" environment using only one of the above approaches. Work is being done in all three areas and this is the only way it can be solved, at least in the forseeable future.

Between the efforts of government and the automobile industry - trucks, sport cars and motorcycles are getting quieter. However, it will take a complete technical breakthrough to lower truck noise much below 82 dBA (at 50 feet). Officials who establish zoning laws are starting to recognize noise

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[4] Using Sound Levels to Gauge Human Response to Noise. H.Botsford, Sound and Vibration, October, 1969.

sensitive areas and there are many industrial and other commercial uses for such land. In addition, architects and builders have the ability to design and construct noise proof buildings. We in the highway industry also have the ability to decrease the noise reaching sensitive areas.

One of the more important technical problems involved with noise is the ability to measure and predict its level in meaningful terms. Noise is a combination of undulating pressure and frequency which has led many experts into converting noise data, often by an octave band analysis, into a rating or index number related to human response. Such ratings usually require rather complex equipment and analysis. Fortunately traffic noise occupies a rather predictable contour in the overall acoustical spectrum and is subject to simple weighted measurements. Thus traffic noise (and most noise) and its annoyance can be well related to the noise level as measured by a sound level meter in dBA.

A sound level meter is a compact, light instrument which reads in decibels (dB) and can be used by any well trained technician. The meter usually has three weighted scales A, B and C which are identified as dBA, dBB or dBC. While the meter is rugged, it is sensitive, and must be kept in calibration. One of the two difficulties in using a sound level meter in a noise survey for planning purposes is the complication entered by use of the L10, L50, L90, etc. concept. The letter "L" stands for sound level and the number is the percent of time that level is exceeded. For instance, if the L10 standard was 70 dBA, then 10% of the time this noise level could be exceeded. Thus, if a noise is measured with a standard sound level meter then the information must be recorded on a graphic recorder so the 10% highs can be eliminated. This is a tedious task but fortunately an instrument house [5] has now developed a modified meter that reads time occupancy in discrete band levels. Such instruments are real time savers.

It is important to note that most laws and court orders concerning traffic noise levels usually refer to a maximum noise with no reference to a percentage of time. Thus, if attenuation measures are taken to reduce noise to an L10 maximum, then the measures taken could possibly still be in violation of the law or court order because the L10 maximum can be exceeded 10% of the time. In order to solve this problem it is the authors opinion that traffic noise attenuation measures should only apply to access controlled highways and that reference to occurrence time should be abandoned. There are three reasons for this; (1) the traffic volumes justifying a controlled access highway are almost always high enough to result in an annoying number of loud trucks, (2) projected noise levels would have to be developed from real life which would automatically recognize better muffling as it takes place, and (3) controlled access is the only highway type lending itself to on right-of-way facilities to attenuate sound.

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[5] Brüel and Kjaer

In any case, a noise level survey [6] along a proposed transportation route uses a noise level meter as the basic measuring tool. There are various other appurtenant instruments that can be used such as a graphic recorder or modified sound level meter which aids in the reduction of the data, but the only instrument really needed is the sound level meter. With this instrument the present or ambient sound to which the locale under study is being subjected can be measured along with the topography and existing buildings. Then, using one of several methods [7] the sound predicted as emanating from the proposed facility can be plotted as sound contours along the side of the right-of-way. Comparison with the existing noise can indicate the sound suppression measures, if any, necessary. For instance, if the measured noise level existing in an industrial area from activity in the area, was found to be 85 dBA and the maximum as projected from the proposed highway was 80 dBA, then no control measures would be needed even though the standards might be 75. After all, suppressing the highway sound would not lower the existing noise.

If, on the other hand, the existing sound measured 60 dBA and the projected was 80, some steps would be needed to lower it to the standard. If proper zoning should not be feasible then there are several steps that can be taken by the highway designer [7]. A depressed roadway will drop the sound level

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[6] Traffic Noise Near Highways - Testing and Evaluation, Beaton and Bourget, Highway Research Board, January, 1973.

[7] Evaluation and Attenuation of Traffic Noise, AASHO Design Guide, 1973.

by over 10 dBA which in itself cuts the loudness by a half as indicated by Figure 1. Other choices could be an extra wide right-of-way, placement of highway within a noise insensitive area, the building of noise barriers, etc. The choice would be dictated by economy. The most predictable attenuator of sound is distance. Sound varies with distance according to the inverse square law. However, it can be affected by surrounding conditions. For instance, a hard or paved surface will enhance a noise more than a planted or plowed field; a wind blowing in the direction of the receiver will also enhance it; a building wall can reflect a sound around a corner, etc. Actually, distance is usually not the best selection due to overall economy and also the phychological aspects of traffic visibility.

A noise barrier can be built of most any material as long as it has sufficient mass, is high enough and has no openings. Practically, any solid wall strong enough to resist the wind load has sufficient mass although a rule of thumb to follow is that it should not weigh less than about 4 pounds per square foot. If sufficient space is available, a planted earth berm is the most effective noise barrier. The necessary height of a barrier for any needed attenuation can be designed [6] to conform to the local conditions.

On a practical basis it is important to remember that most disturbing traffic noise is caused by heavy diesel trucks, that a truck makes more noise going uphill and pulling away from a stop sign or signal than when travelling on the level. Further, contrary to popular belief, tire noise from a smooth surface is louder than from a textured (rough) surface.

In summary, traffic noise can be annoying when it exceeds 70 dBA in sensitive areas such as houses, hospitals and schools. However, it is tolerated to much higher levels in less sensitive areas. So proper zoning can be very effective. The three effective elements in controlling sound are: (1) suppress (muffle) the vehicle; (2) provide distance by zoning to insensitive areas; and (3) use proper design to block the sound from the recipient.